



Prifysgol Cymru  
Y Drindod Dewi Sant  
University of Wales  
Trinity Saint David

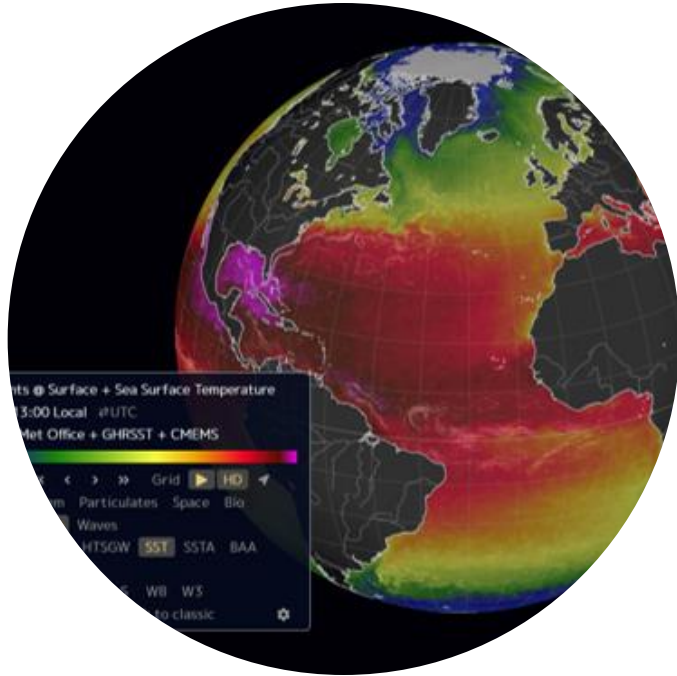


ACNA5001

# COASTAL DEFENCE: HARD AND SOFT ENGINEERING

ALISSA FLATLEY

# AIM



We will look at hard and soft engineering approaches for coastal protection, economic development and ecosystem management.

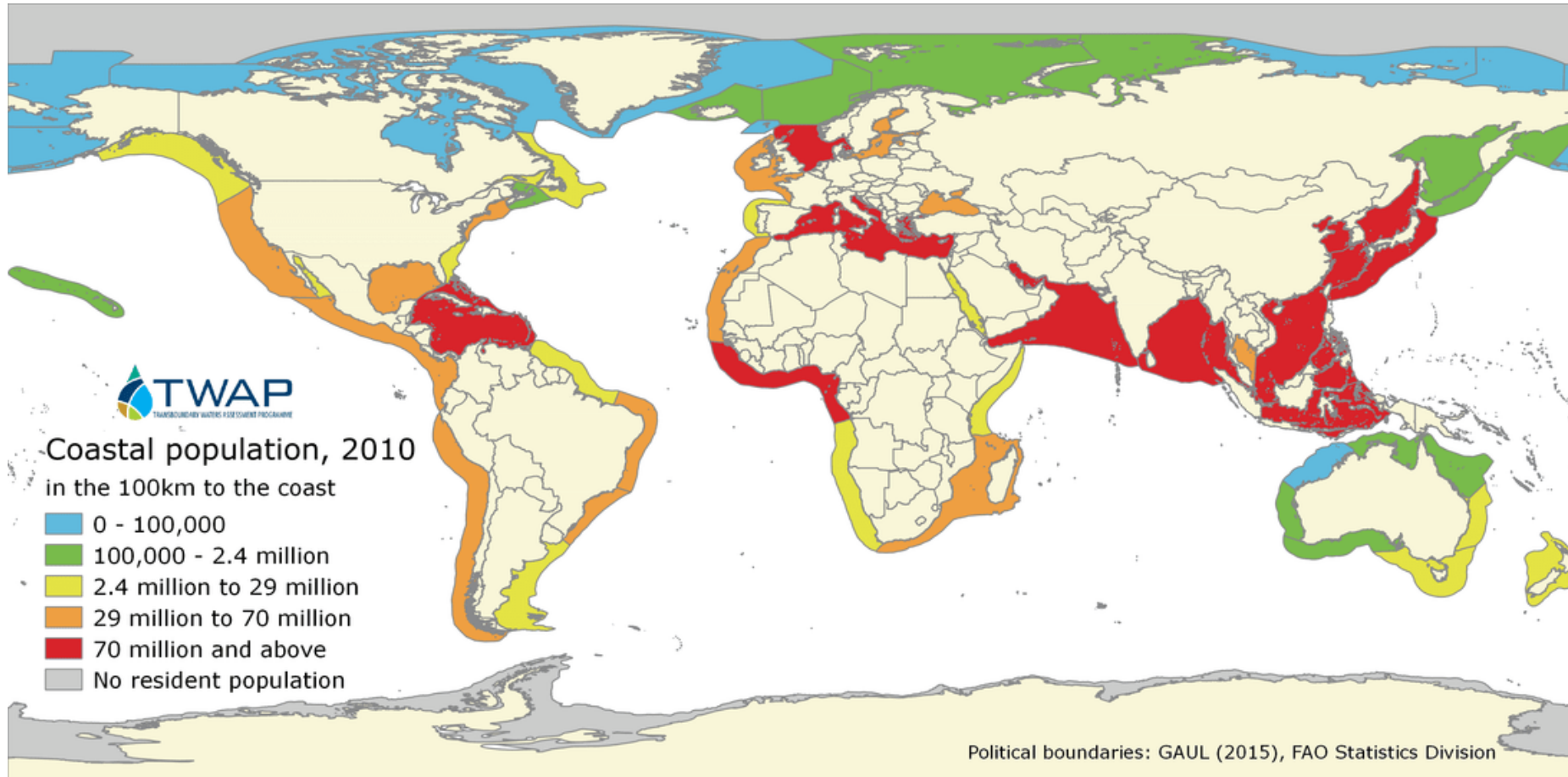
[earth :: a global map of wind, weather, and ocean conditions \(nullschool.net\)](http://nullschool.net)



## CONTENT

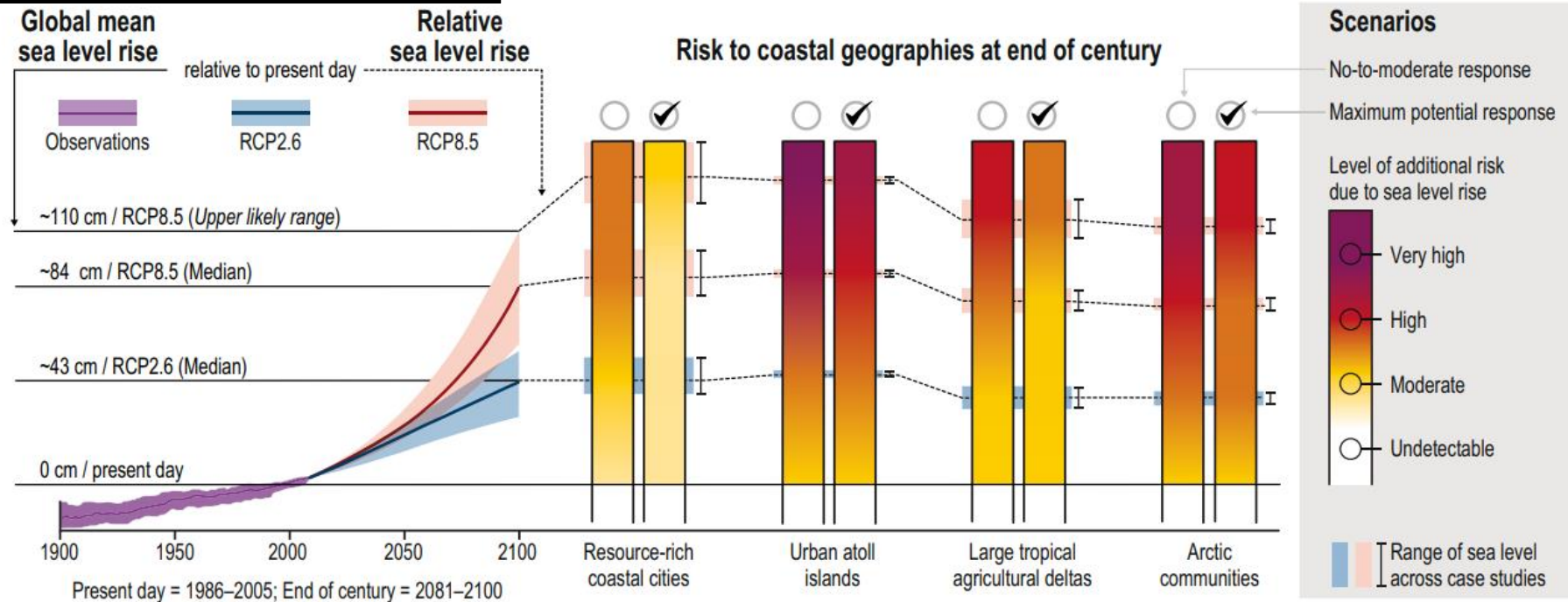
- 1) Quantifying pressure to coastal areas
- 2) Hard Engineering (Hannah Williams)
- 3) Soft Engineering
- 4) Blended Approaches (Activity)

# INTRODUCTION



50 % of global population lives in the coastal zone (Small & Nicholls, 2003)  
Coastal population density is **3 x higher** than the global average

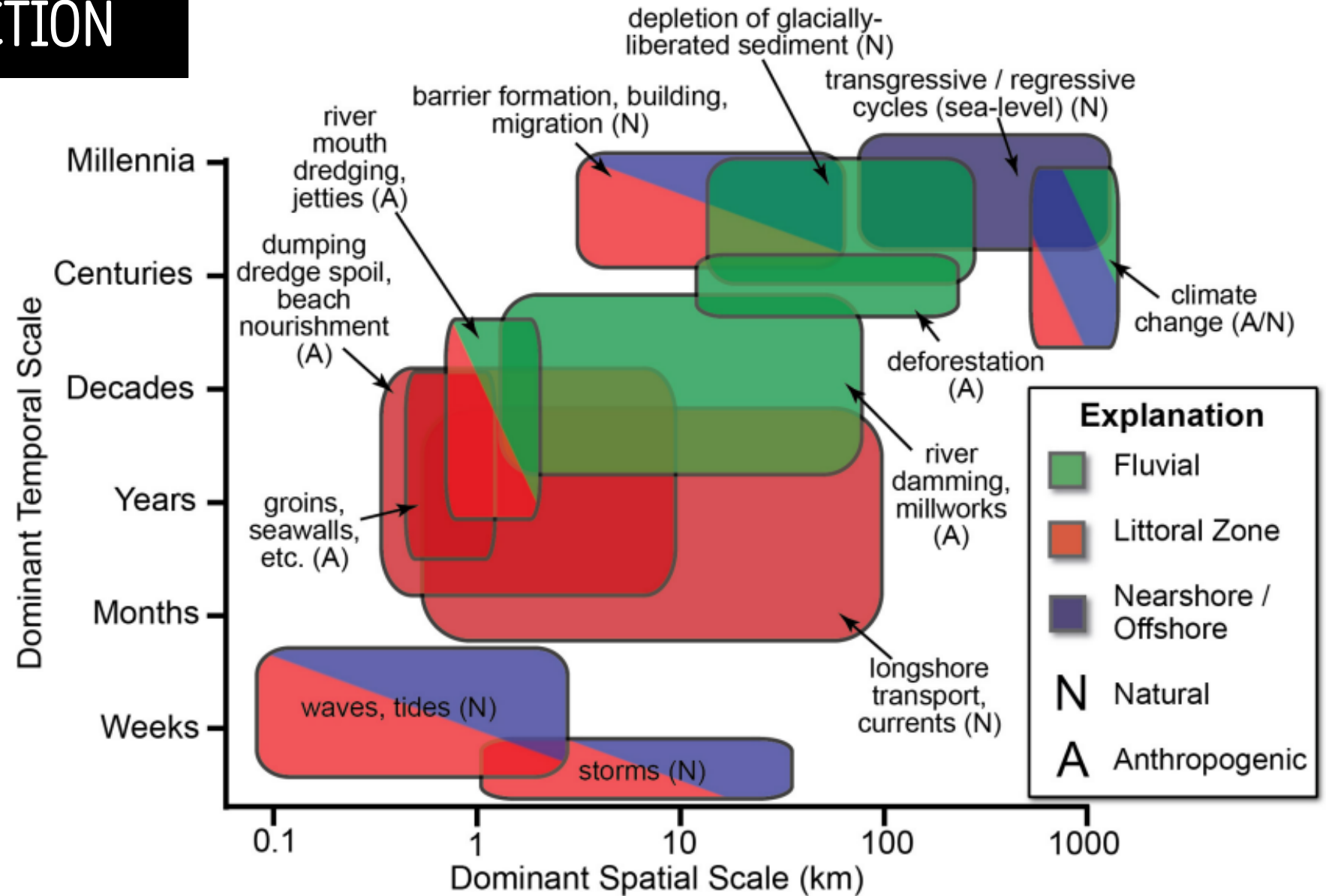
# INTRODUCTION



Rates of change are increasing - makes this a very relevant topic and job

**Under RCP8.5, the rate of SLR will be  $15 \text{ mm yr}^{-1}$  ( $10\text{--}20 \text{ mm yr}^{-1}$ , *likely range*) in 2100, and could exceed several  $\text{cm yr}^{-1}$  in the 22nd century.** These high rates challenge the implementation of adaptation measures that involve a long lead time, but this has not yet been studied in detail. {4.2.3.2, 4.4.2.2.3}

# INTRODUCTION



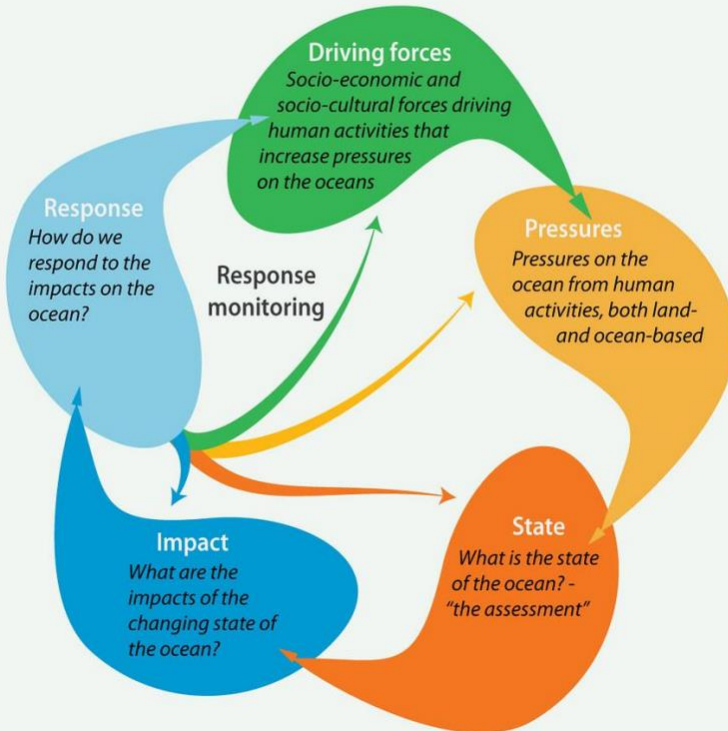
People can also affect beach stability over multiple scales

# INTRODUCTION

Last week we looked at the DPSIR framework  
Shoreline management plans (SMP) and sea level rise.....

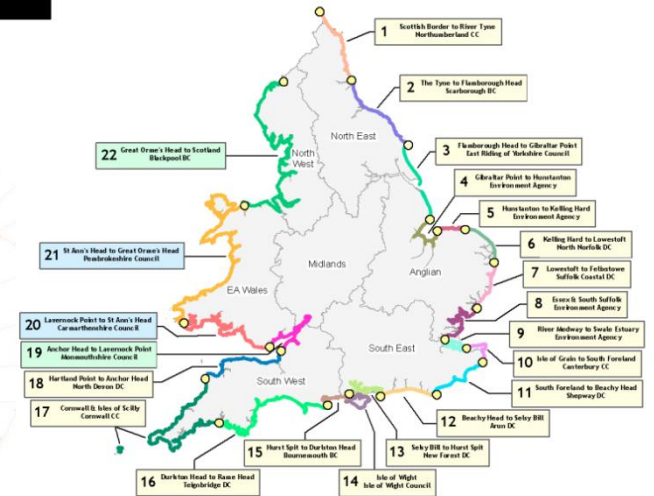
## The levels of DPSIR framework

- Driving forces - Pressures - State (of the oceans) - Impacts - Responses



## Shoreline management plans

- ➔ Hold the Line
- ➔ No Active Intervention
- ➔ Managed Retreat
- ➔ Advance the Line



# HARD ENGINEERING

DR. HANNAH WILLIAMS

TIME FOR A BREAK – 5 MINS



# BEACH NOURISHMENT

- Beach nourishment refers to constant replenishment of large quantities of sand to the beach system. Beach is therefore extended seawards, leading to improvement of both beach quality and storm protection. Usually dredged (Various types of dredging) offshore and planted in required area.
- Needs to be carefully considered not to cause problems
  - Short term mortality
  - Burial
  - Reduced light
  - Toxicity
  - Can cause erosion
  - Increased development pressure because of cost and misguided sense of security
  - High proportions of suspension in water column



## SOME ISSUES

- Expensive and impractical to constantly transport large quantities of sand to fill up beach. Imported sand that can be continuously eroded and transported away could have serious consequences on wildlife living within coastal environment.
  - E.g. Coral reefs at Waikiki Beach of Hawaii are destroyed as imported sand gets washed out to sea and covers the corals. Corals are deprived of sunlight they need to survive
  - E.g. Singapore – Large scale land reclamation along coast has led to muddy and polluted water and has destroyed coral reefs.
- Often to 'save' £ dredging occurs in <40ft water which is generally fine sediment which is easily eroded and creates a steep beach profile e.g. Wrightsville , North Carolina in 1965

# BEACH NOURISHMENT

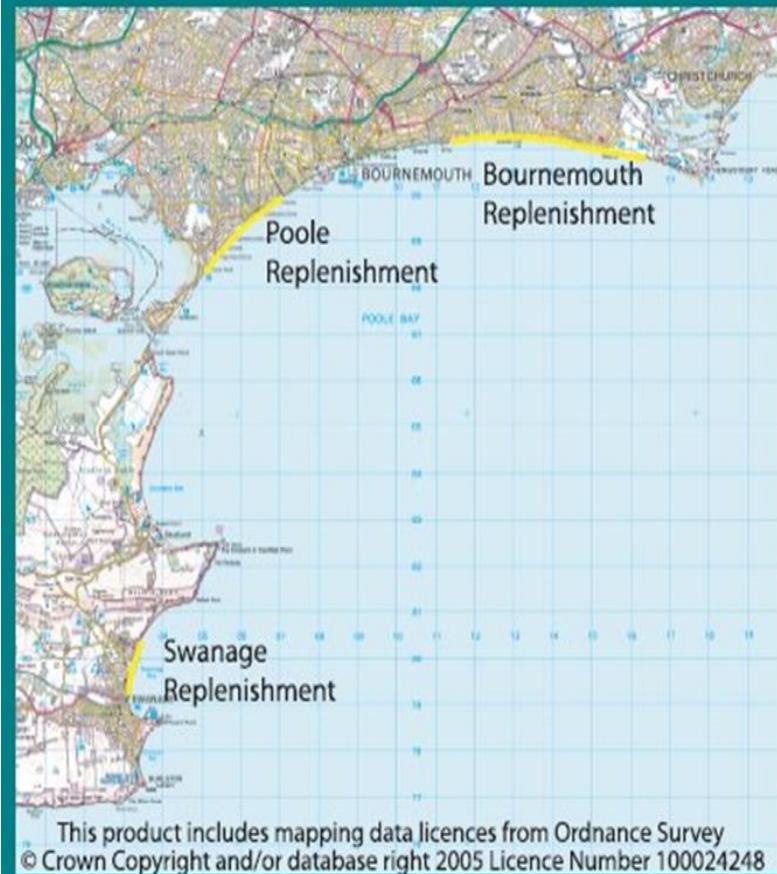
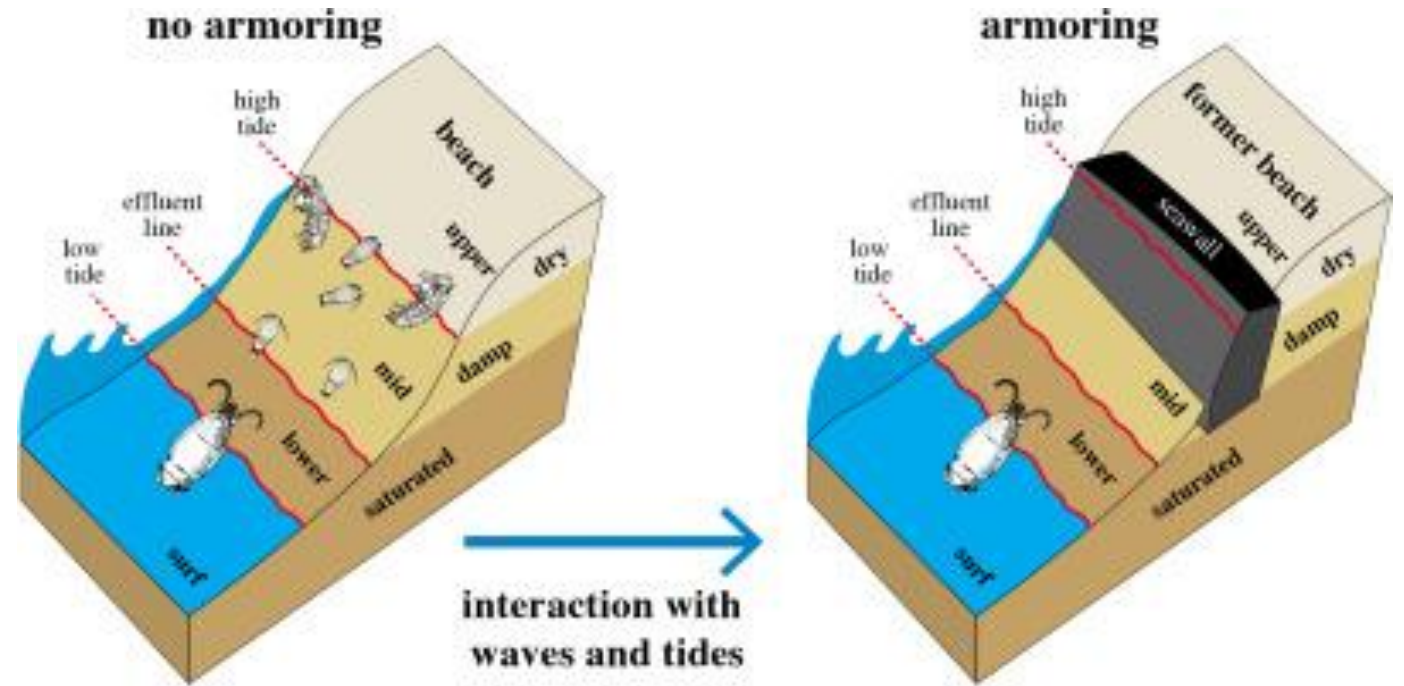


Figure Beach replenishment in Miami, Fla. This project restored a declining tourist industry and paid for itself in revenue.

# INTER-TIDAL ZONES



- Moller & Spencer, (2001) highlight how intertidal zones help protect the coast
- An 80m wide saltmarsh can reduce wave energy by 40% (Brampton, 2002)
- Moller & Spencer, (2001) note in their studies in Essex that a 10m saltmarsh reduced wave energy by 44% and height by 79%.
- Cooper (2005) found if the saltmarsh is >300m then energy can be reduced by 97% and height by 91%

# OYSTER REEF

Oyster reef living shorelines have been proposed as an effective alternative to traditional coastal defence structures (e.g. bulkheads, breakwaters), with the benefit that they may keep pace with sea-level rise and provide co-benefits, such as **habitat provision**.

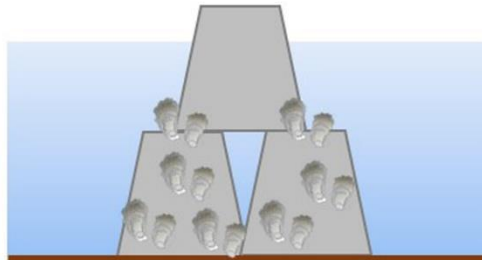
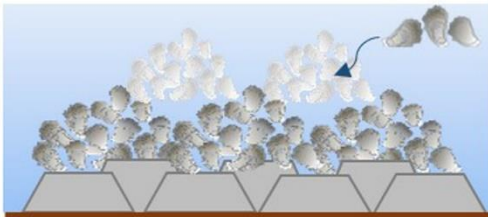
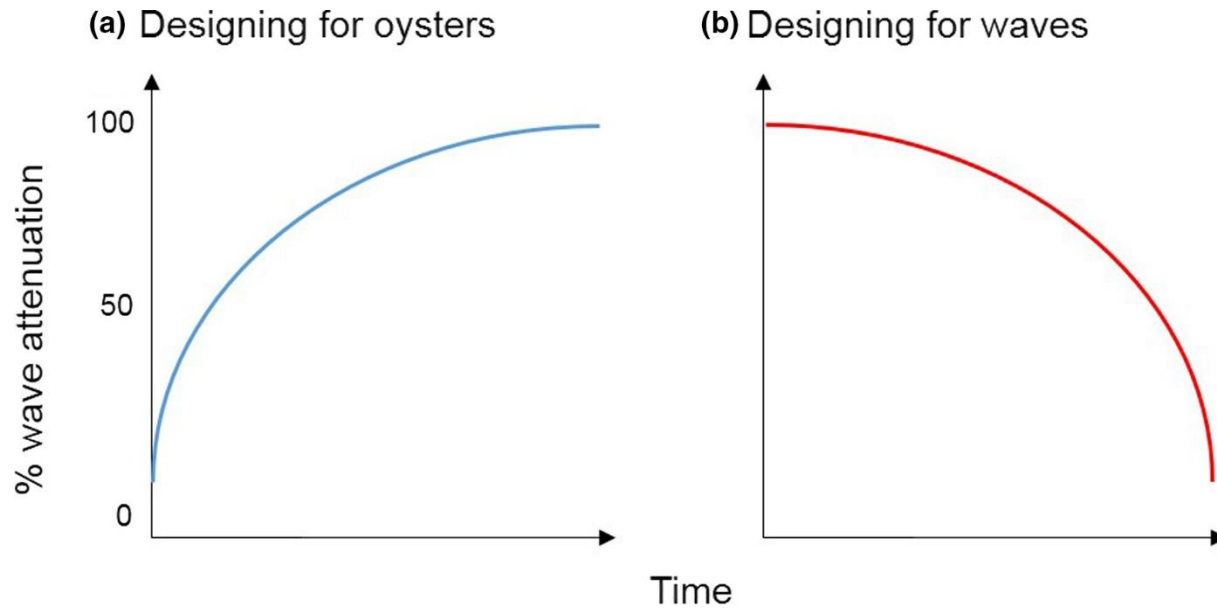
However, there remains uncertainty about the effectiveness of shoreline protection provided by oyster reefs, which limits their broader application.

[The application of oyster reefs in shoreline protection: Are we over-engineering for an ecosystem engineer? - Morris - 2019 - Journal of Applied Ecology - Wiley Online Library](#)

Artificial oyster reef, Eastern Scheldt



# OYSTER REEF



[The application of oyster reefs in shoreline protection: Are we over-engineering for an ecosystem engineer? - Morris - 2019 - Journal of Applied Ecology - Wiley Online Library](#)

Artificial oyster reef, Eastern Scheldt

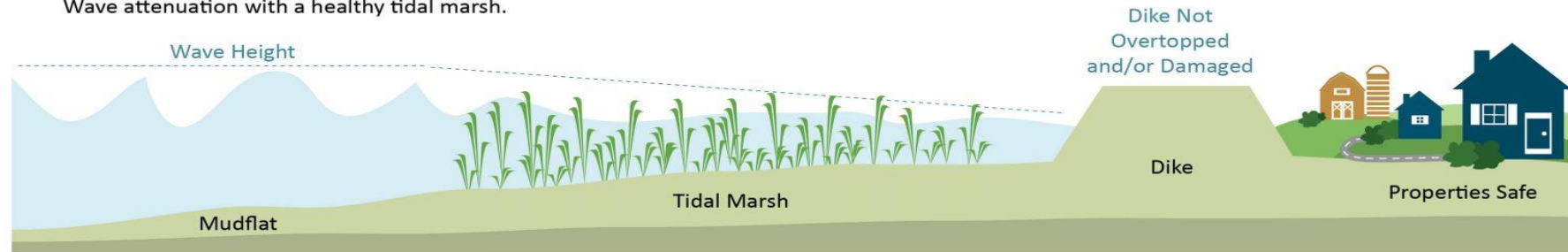


# SALT MARSH

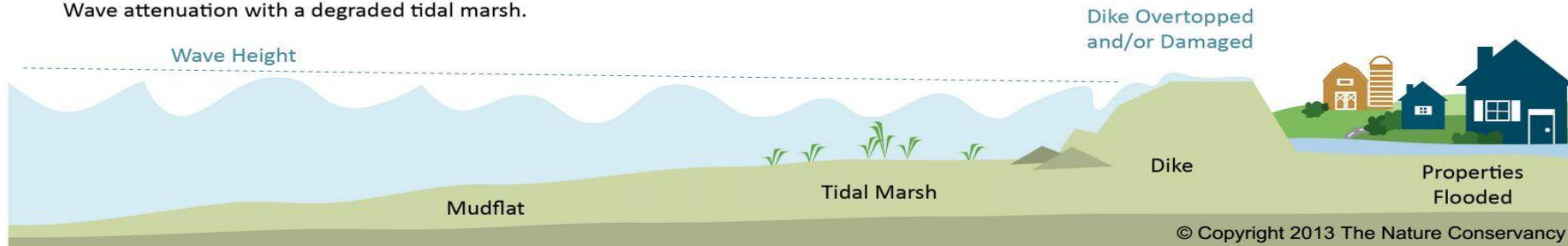
## Coastal Defense

Coastal Defense quantifies how natural habitats (oyster reefs, tidal marshes, seagrass ...) protect coastal areas by reducing wave-induced erosion and inundation. It uses standard engineering techniques to help you estimate how and where to restore or conserve critical habitat, and increase the resilience of your coastal community and infrastructure.

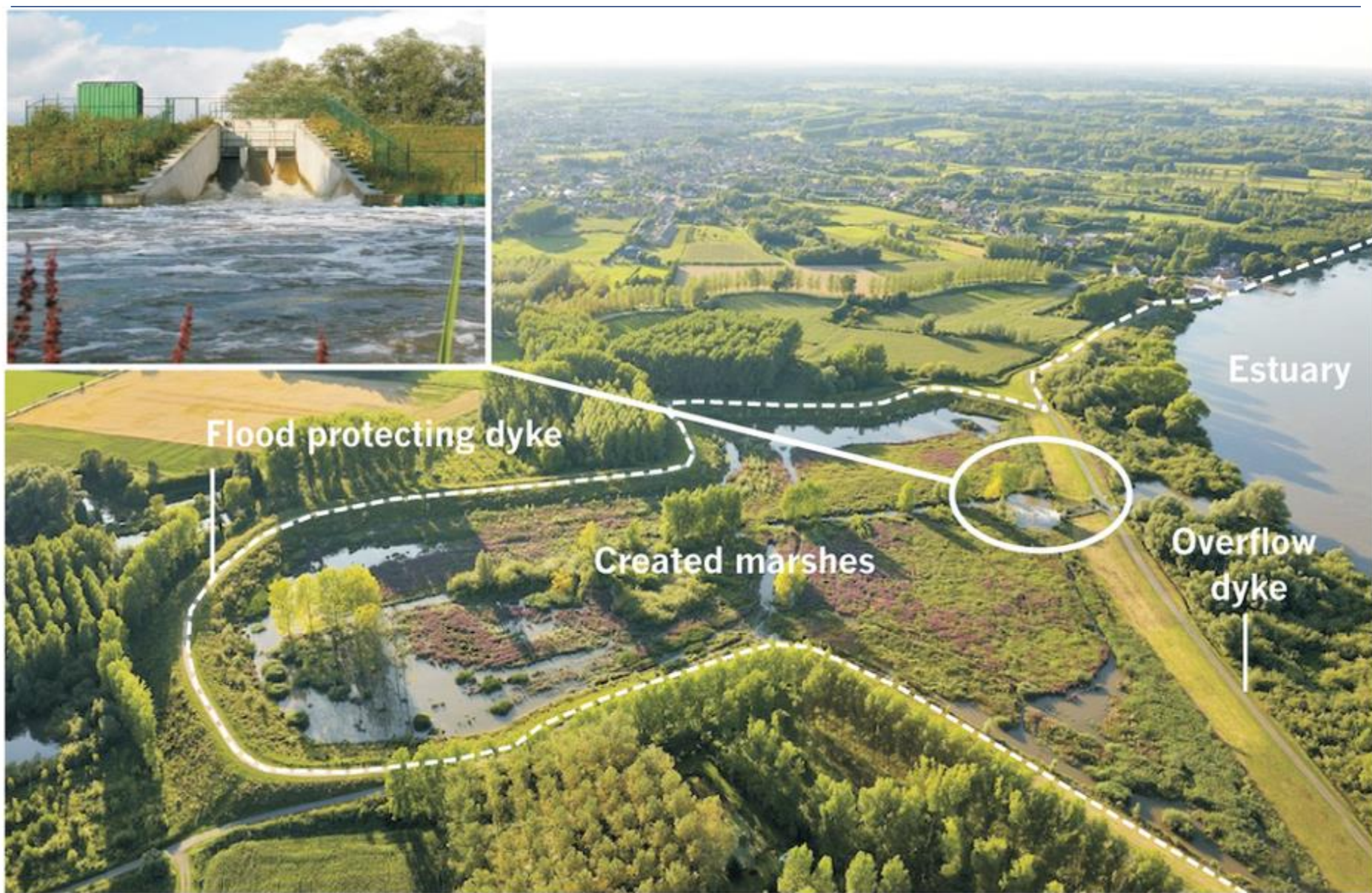
Wave attenuation with a healthy tidal marsh.



Wave attenuation with a degraded tidal marsh.

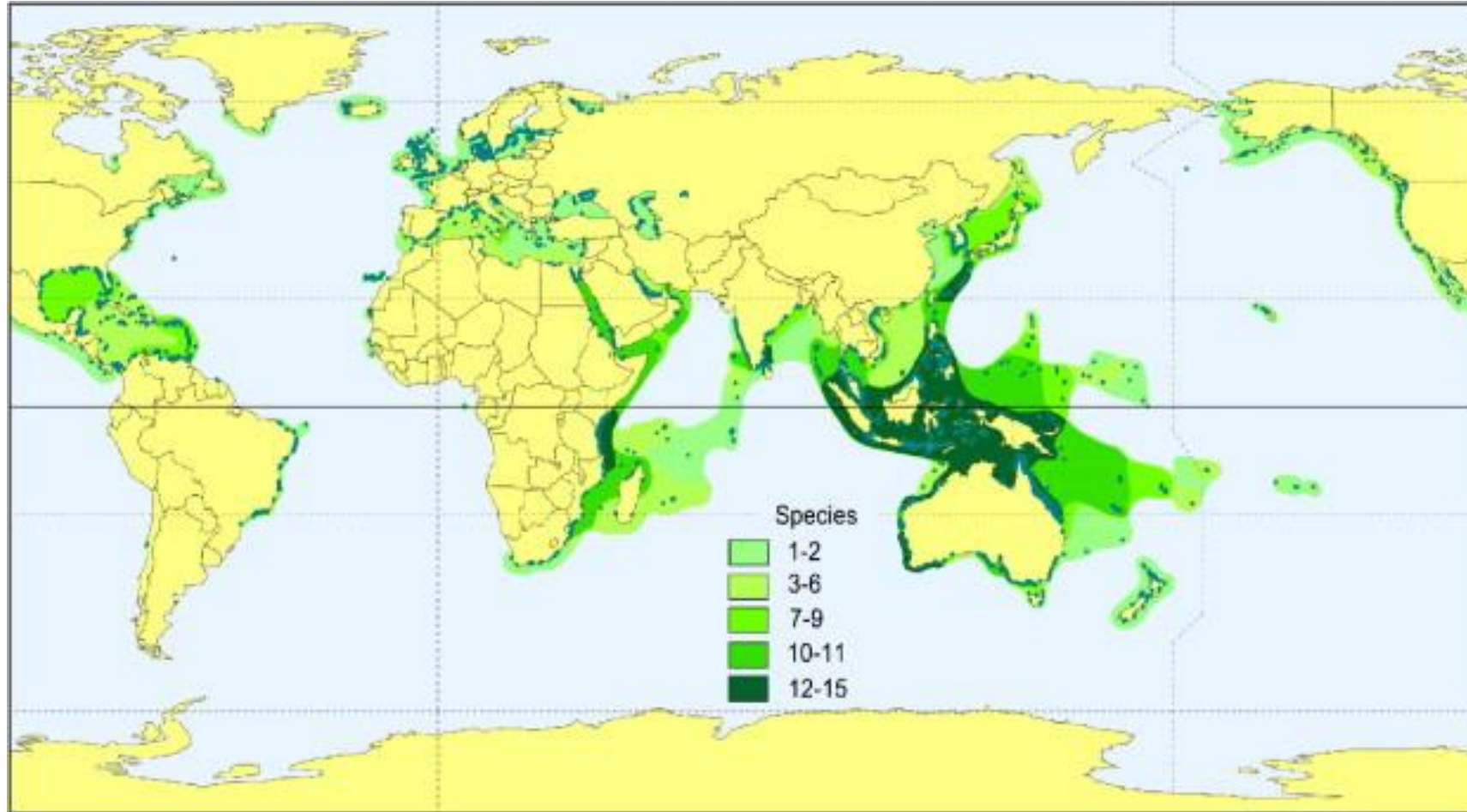


Loughor is the 4<sup>th</sup> largest saltmarsh in the UK and a Ramsar site (Barne et al., 1995) and is macro-tidal (max. 7.5m). Natural coastal defence but the area seems to have reduced since the industrial revolution (Bristow & Pye, 2003)



# SEAGRASS EXTENT

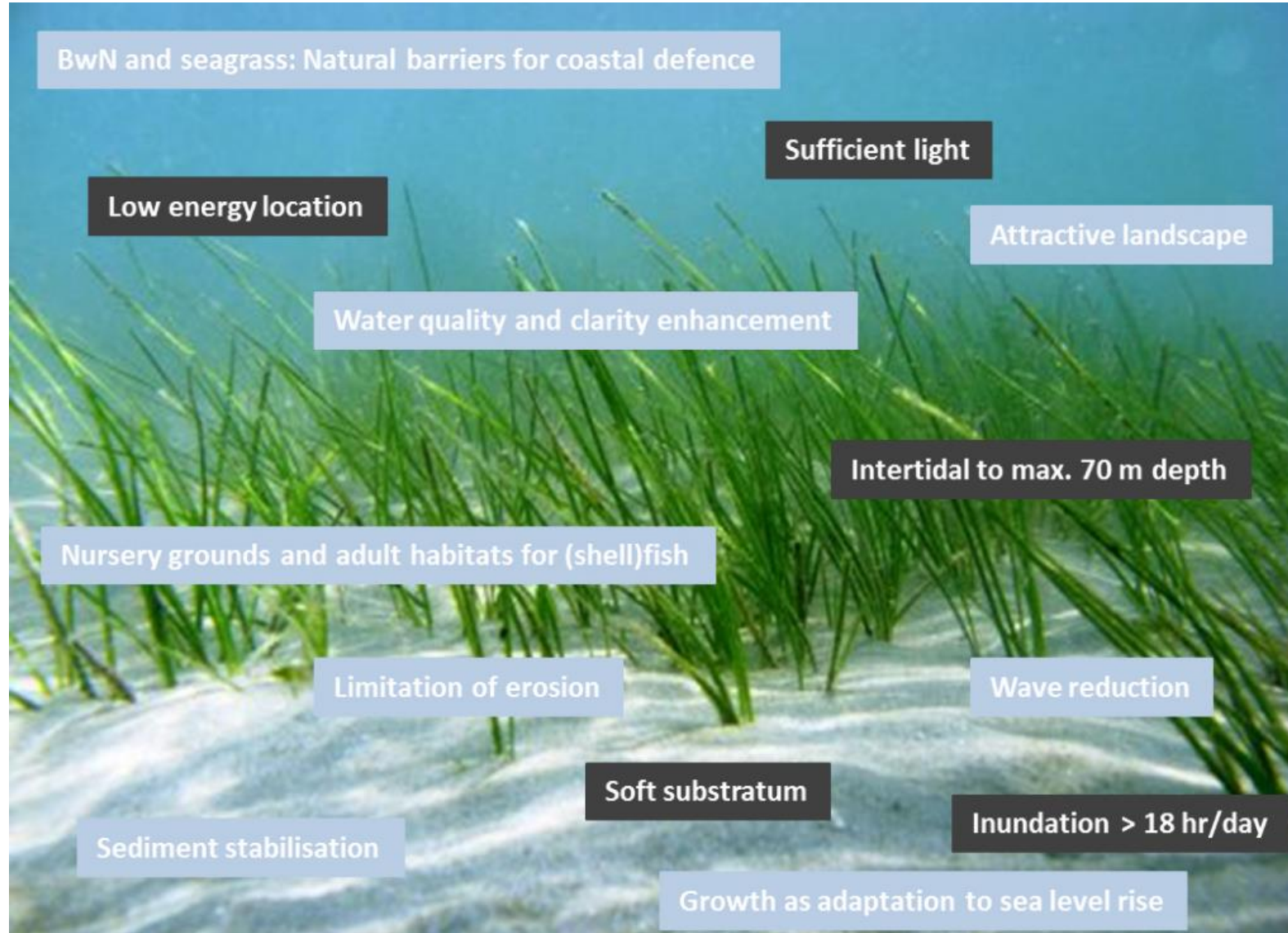
Seagrass distribution. Source: UNEP RAC/SPA (2011)



- Human activities such as urban and industrial runoff, urban and port infrastructure development and dredging are currently among the major threats to seagrass ecosystems worldwide (Grech et al., 2012).

# SEAGRASS

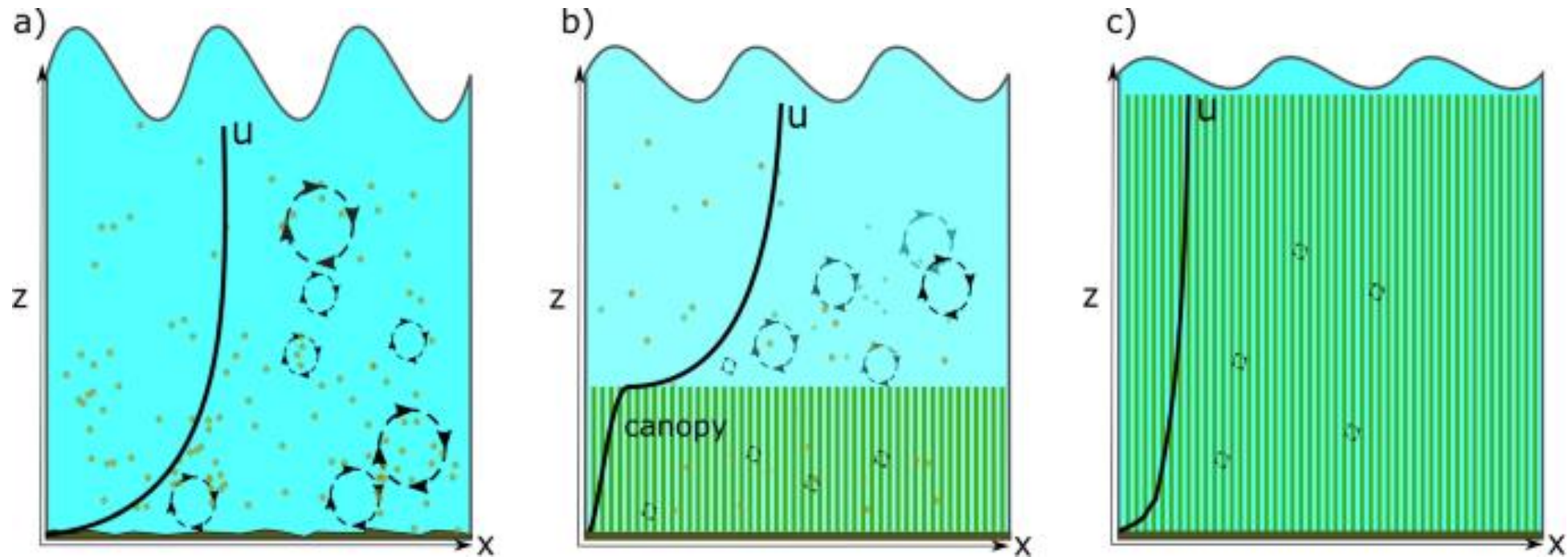
Erosion control and  
habitat benefits



[Get Started - EcoShape](#)

# SEAGRASS (WADDEN SEA)

[Evaluation of seagrass as a nature-based solution for coastal protection in the German Wadden Sea | Ocean Dynamics \(springer.com\)](#)



Schematic of the effect of seagrass on hydrodynamics, waves, and sediment dynamics. a shows the boundary layer flow without seagrass and high shear generation in the rough bottom layer. b is the situation with submerged canopy (green lines), which dampens velocities in the bottom layer and increases shear generation above the canopy. c is the situation with fully emerged canopy, which dampens velocities over the whole water column and reduces shear over the whole water column.

# MANGROVES

- Mangrove forest consists of trees and shrubs that can tolerate regular flooding by seawater.
- This tolerance is due to one of the most distinct characteristics of the mangrove trees: aerial roots which are part of the day exposed to the air, and thereby enable them to survive tidal inundation and anoxic (depleted dissolved oxygen) sediments.
- Guardians of the coast 25 mins



# MANGROVE ZONATION

- Planting of Mangroves (-) Not all coastal regions can support mangroves, especially in coastal regions with destructive waves. As sediments build up along coast after planting mangroves, depth of coast may become shallower and thus affect port activities – (E.g. Pose a problem for countries like Singapore that depends heavily on maritime trade.)

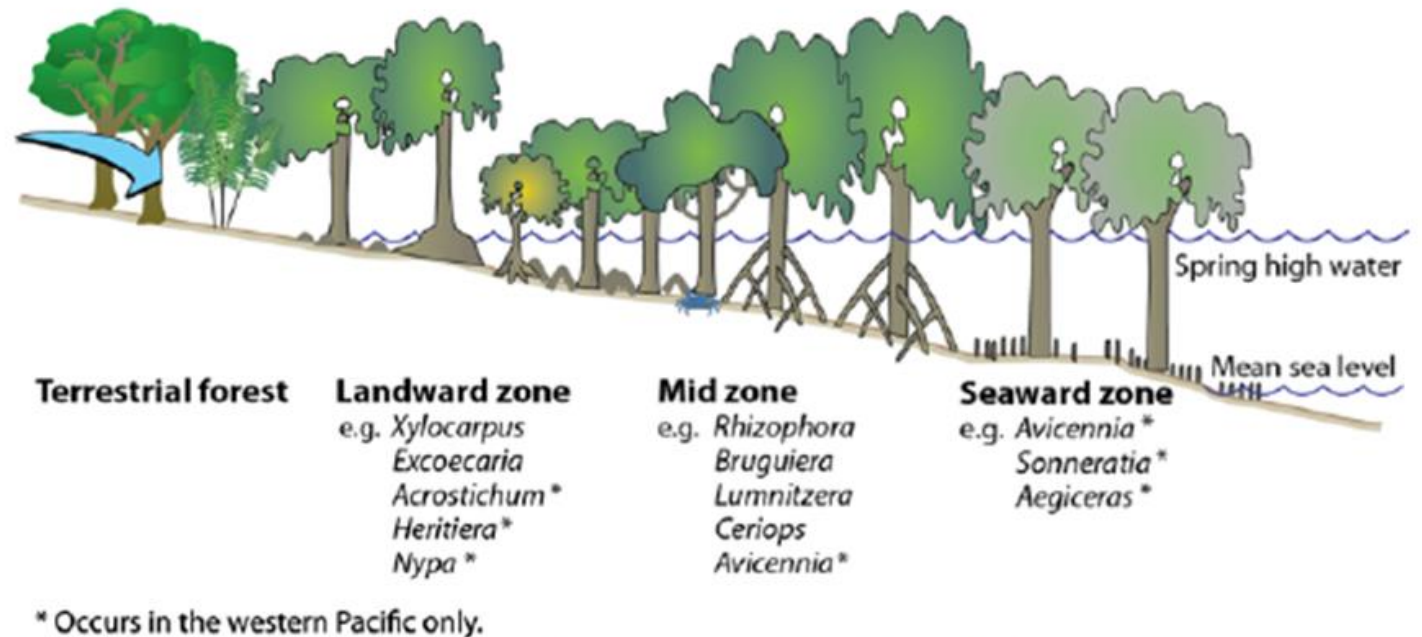
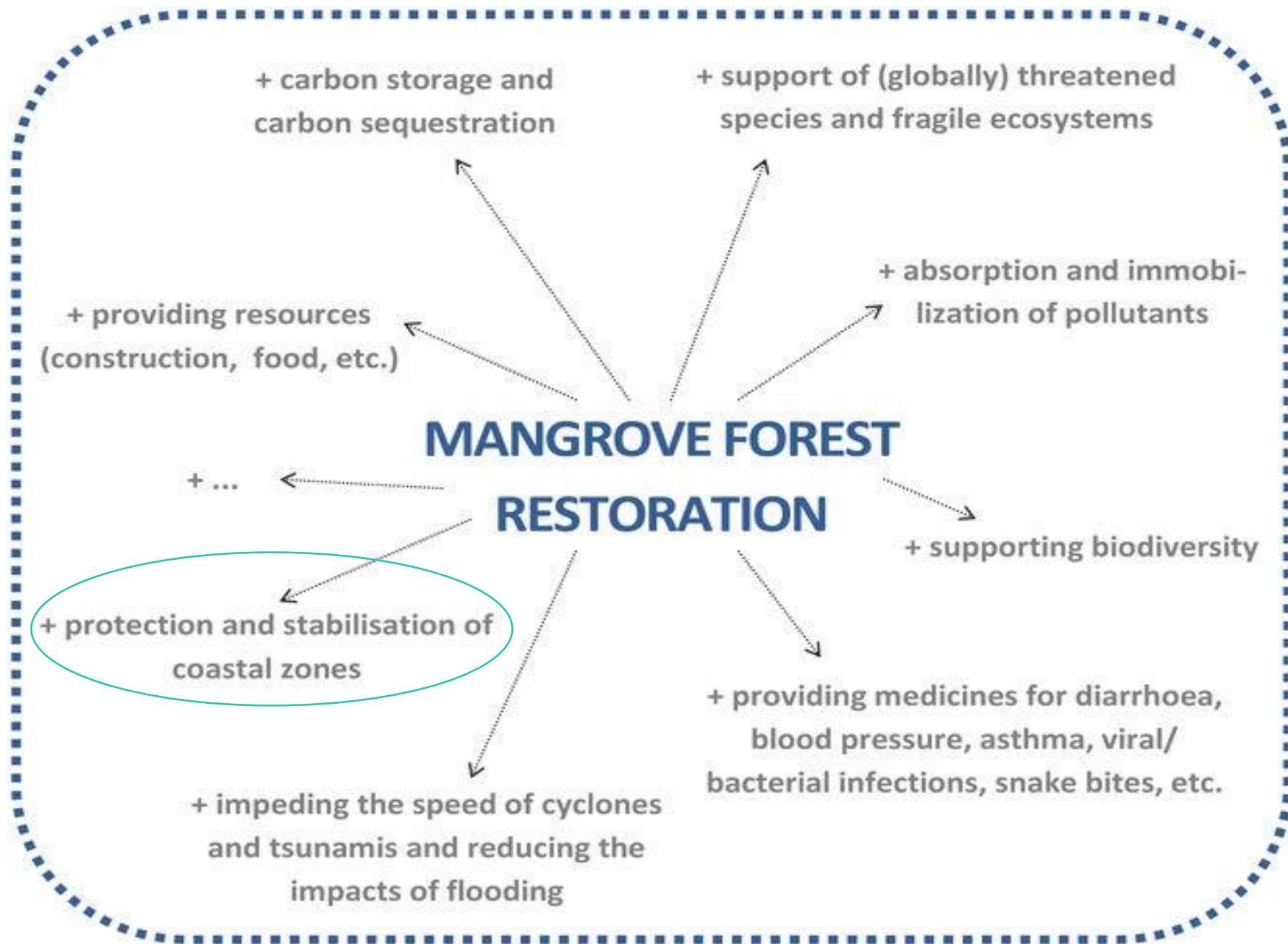
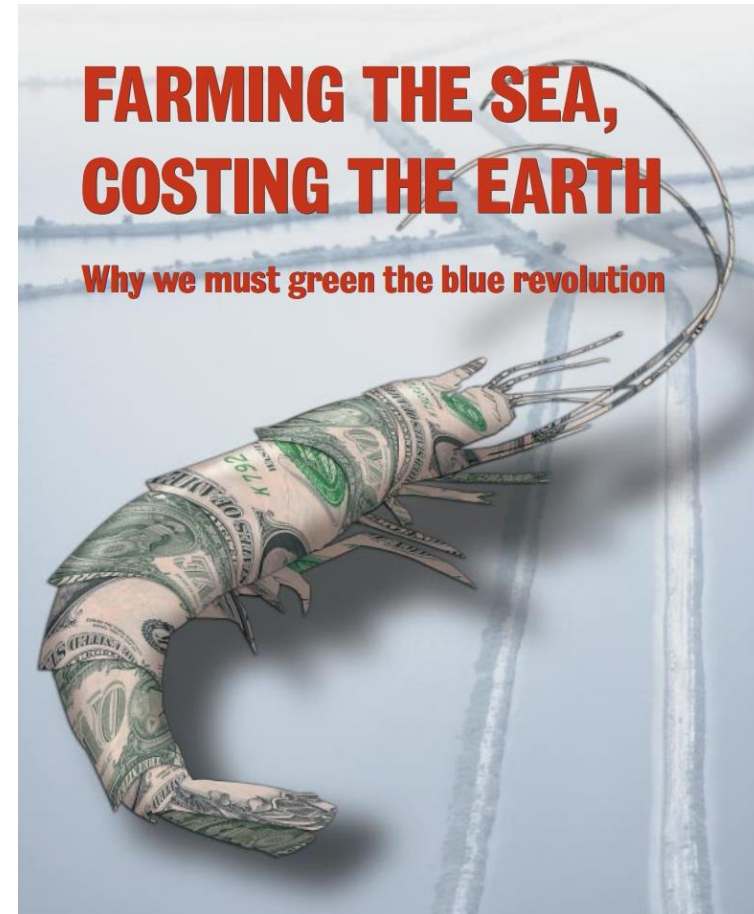


Figure 6.1 The three zones typical of mangrove habitats in the tropical Pacific, showing the differences in mangrove species typical of each zone.



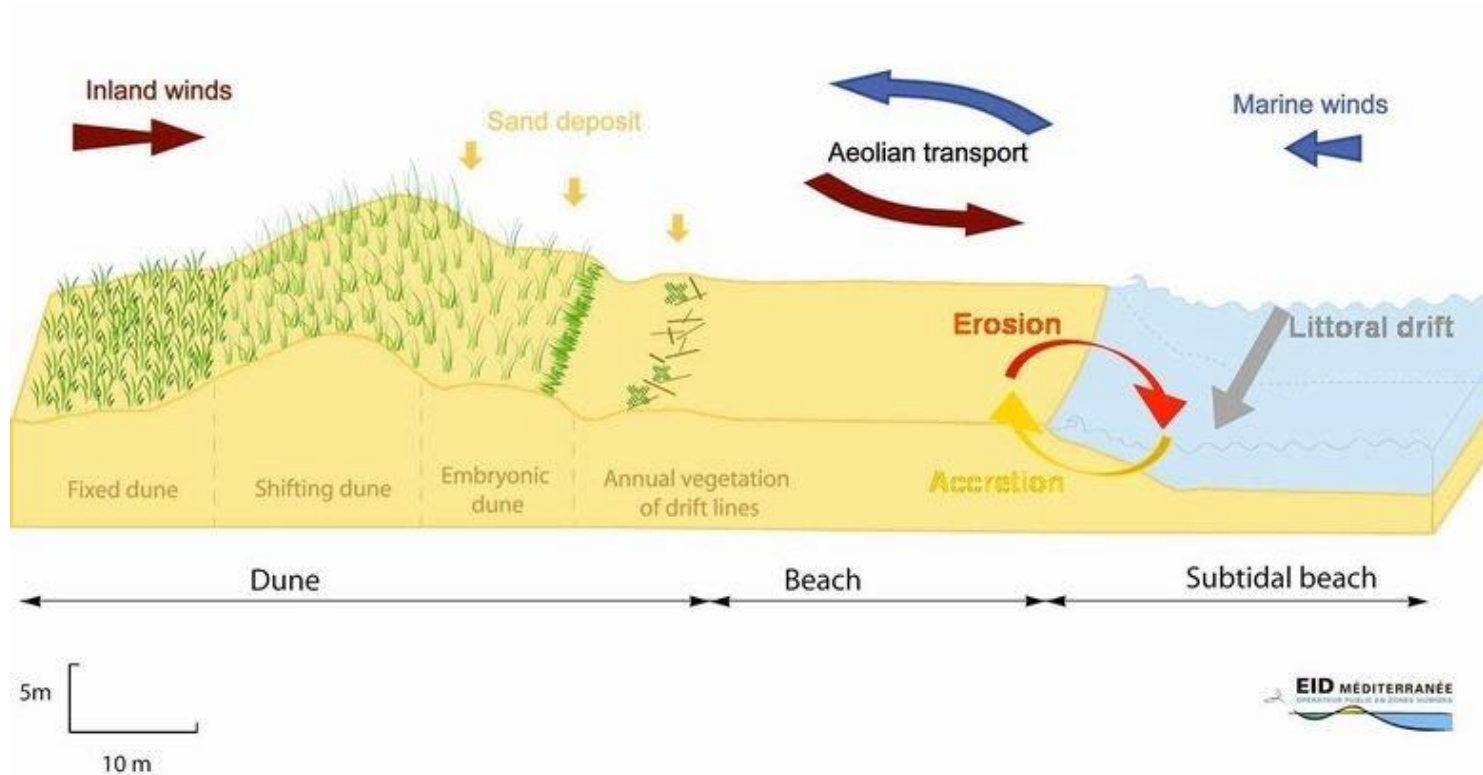
# CONSERVATION

- Shrimp farm pressure [Farming The Sea, Costing The Earth \(ejfoundation.org\)](http://ejfoundation.org)
- Protection from wave erosion: Mangroves



# DUNES

[Swept away: \\$500,000 sand dune built to protect US homes disappears in days | Massachusetts | The Guardian](#)



**Swept away: \$500,000 sand dune built to protect US homes disappears in days**

**Property owners dumped 15,000 tons of sand in a Massachusetts town to fend off dangerous tides, but it was swept away in 72 hours**



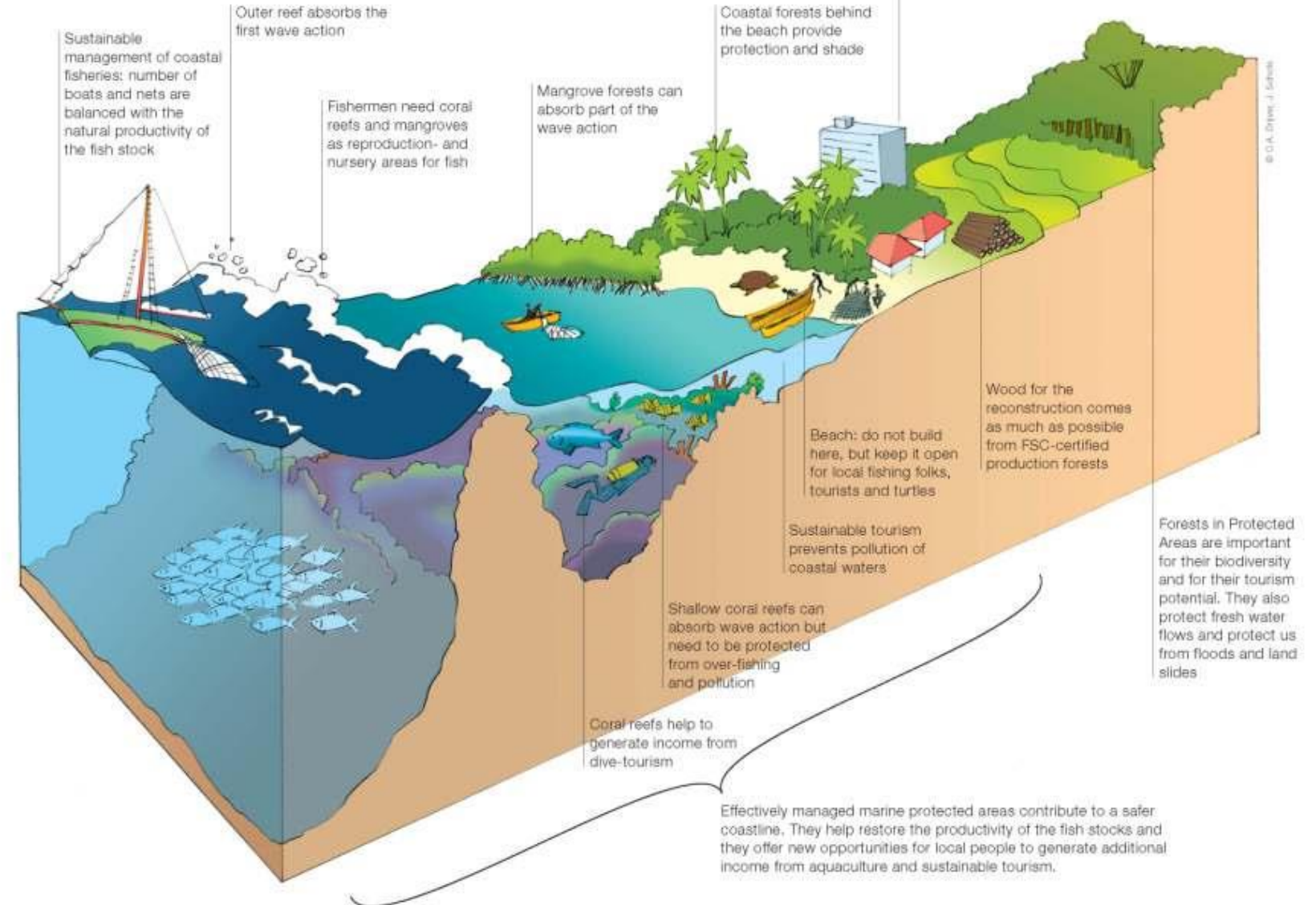
Salisbury sees several large storms each year. A photo of East Beach Road in Westport, Massachusetts, battered after heavy storms in January 2024. Photograph: Peter Pereira/AP

A sand dune that cost homeowners on a [Massachusetts](#) beach more than half a million dollars to construct has washed away after just three days.

## CORAL

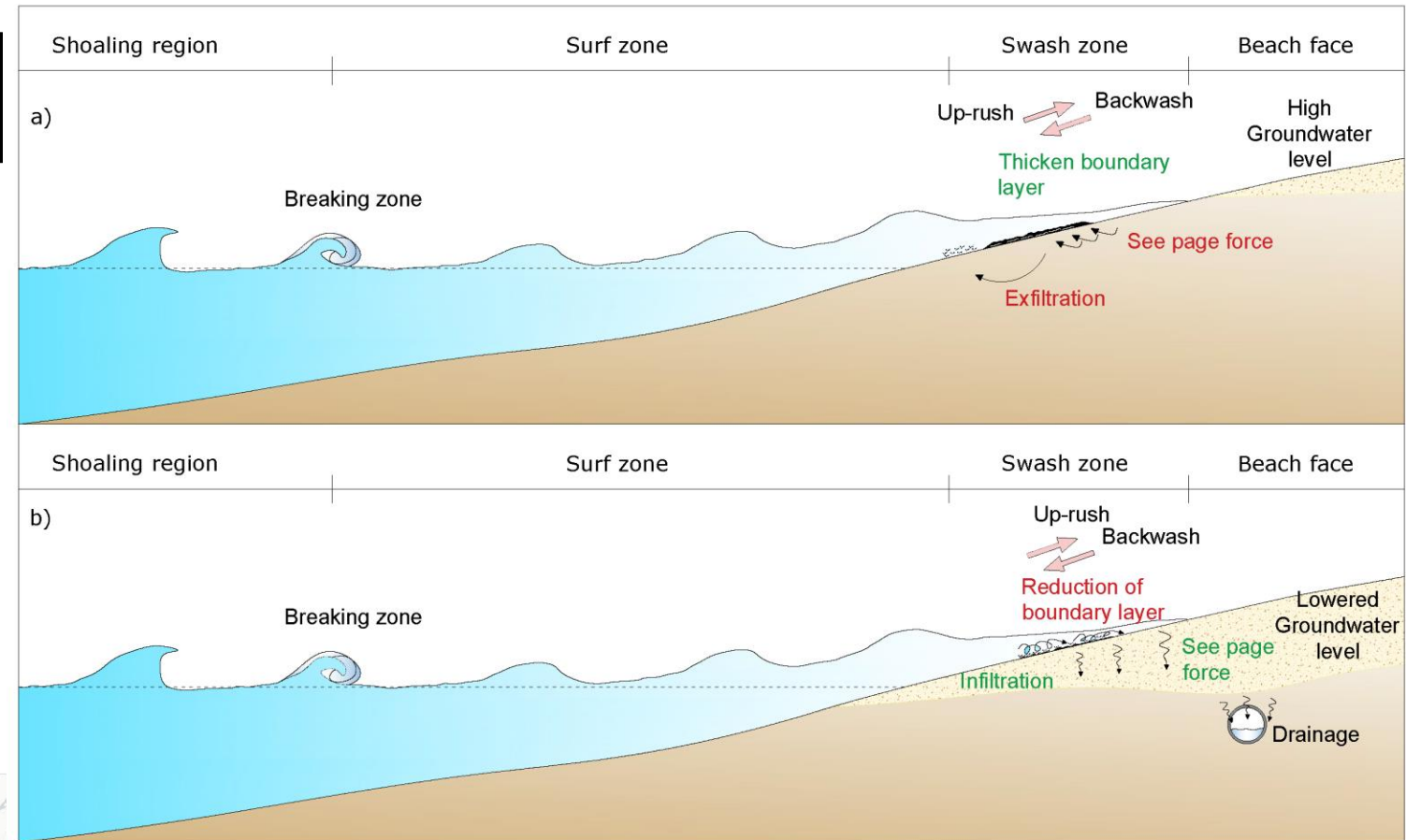
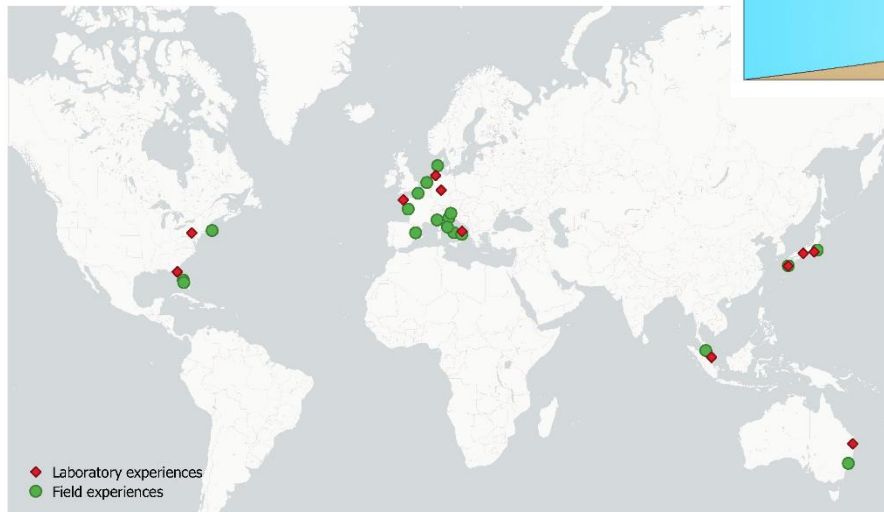
## Securing the future after Tsunami

The concept of a well reconstructed coastal zone. Coastal protection as well as the long term security of food and income enhanced when sustainable tourism and -fisheries management are combined with the rehabilitation and management of natural resources



# BEACH DRAINAGE

- [JMSE | Free Full-Text | Beach Drainage System: A Comprehensive Review of a Controversial Soft-Engineering Method \(mdpi.com\)](#)



- Application of the beach drainage system (BDS) as a tool able to modify the natural dynamics of groundwater table at sandy beaches.
- Due to the drainage, the thickening of the layer of dry sand makes the solid grains less prone to be mobilized by the action of the waves at the swash zone, where interaction phenomena between the percolating and the incoming water lens take place.

# WORKING WITH NATURE & HYBRID INTERVENTIONS (ACTIVITY)

- Find an example of a soft or hybrid intervention (e.g. a mixture of hard and soft engineering) not covered here.
- Summarise the approach
- How effective has it been? If it has not been constructed yet, can you identify any key risks?

[WWF Nature-based Solutions Database Map \(arctgis.com\)](https://arctgis.com/)



## WORKING WITH NATURE & HYBRID INTERVENTIONS (ACTIVITY)

- Compromise or cosmetic strategy?
- Temporary hard infrastructure – a natural approach can take time to establish and hard infrastructure can be used to temporarily reduce disturbances.
- Nature-based solutions: Creating a living shoreline in Louisiana



# WORKING WITH NATURE & HYBRID INTERVENTIONS (ACTIVITY)

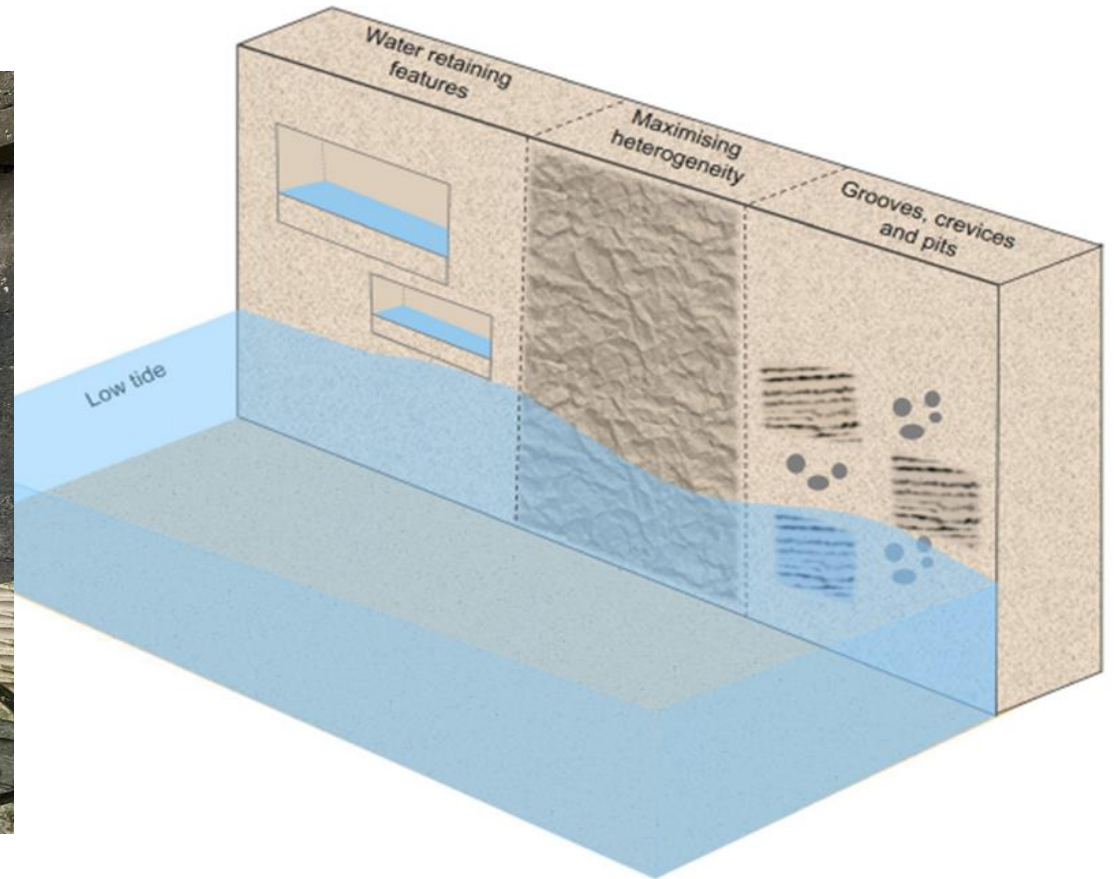


Fig. 6 Schematization of possible nature-based adaptations for seawalls. Interventions should be positioned to ensure that they are submerged during high tide

# WORKING WITH NATURE & HYBRID INTERVENTIONS (ACTIVITY)

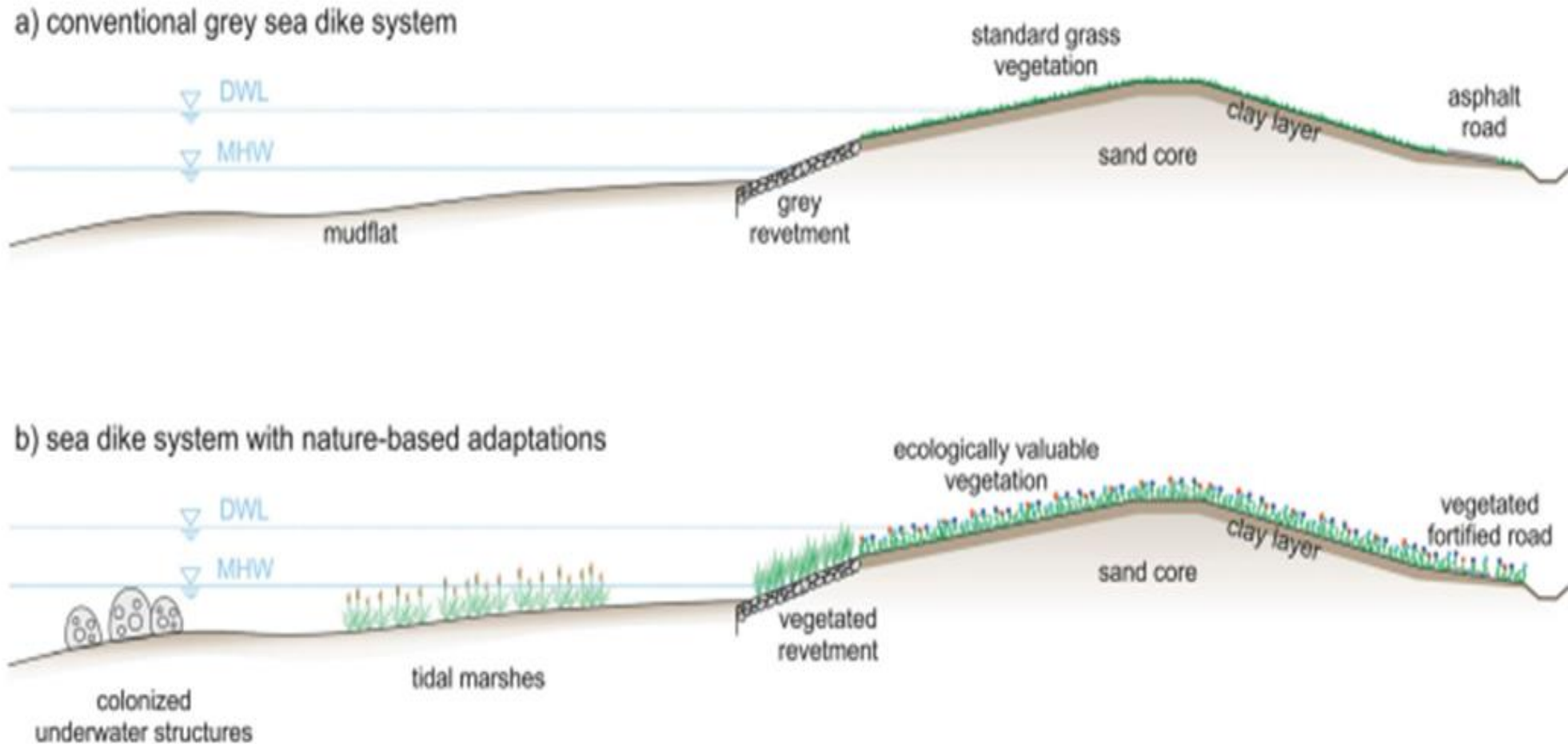
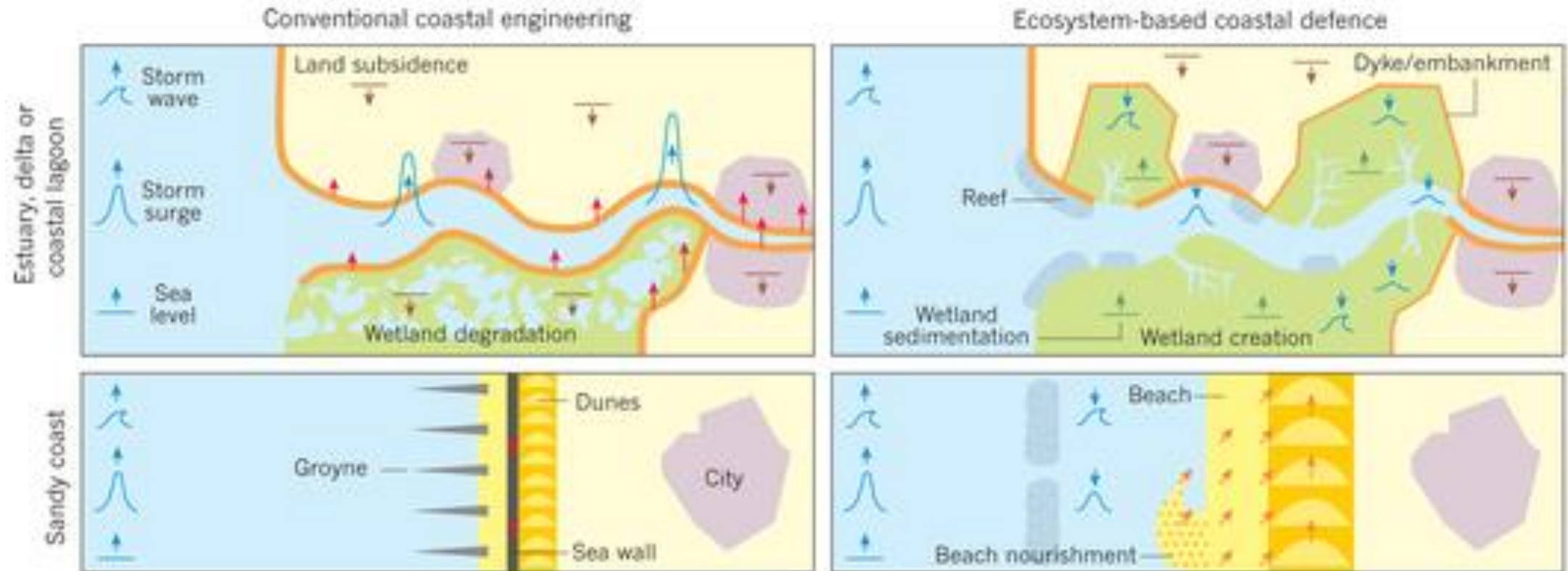


**Fig. 4** **a** Conventional grey sea dike system. **b** Sea dike system with nature-based adaptations

# ECOSYSTEM BASED COASTAL DEFENCE



Temmerman et al (2013) Ecosystem-based coastal defence in the face of global change Nature 504

# NEXT WEEK...

| Week | Session Date | Topic                                           | Lecturer | Pre-Lecture Prep | Post-Lecture Work | Assessment      |
|------|--------------|-------------------------------------------------|----------|------------------|-------------------|-----------------|
| 12   | 12-Jan-24    | Animal Physiology                               | EA       |                  |                   |                 |
| 13   | 19-Jan-24    | Wildlife Ecology                                | EA       |                  |                   |                 |
| 14   | 26-Jan-24    | Overfishing                                     | AF       |                  |                   |                 |
| 15   | 02-Feb-24    | Cetacean Science                                | RJ       |                  |                   |                 |
| 16   | 09-Feb-24    | Censuses and Surveys                            | EA       |                  |                   |                 |
| 17   | 16-Feb-24    | Mapping and Monitoring (GIS)                    | AF/EA    |                  |                   |                 |
| 18   | 23-Feb-24    | Species Response to Climate Change              | EA       |                  |                   |                 |
| 19   | 01-Mar-24    | Ocean Warming and Acidification                 | EA       |                  |                   |                 |
| 20   | 08-Mar-24    | Sea Level Rise and Adaptation                   | AF       |                  |                   |                 |
| 21   | 15-Mar-24    | Hard and Soft Engineering                       | AF       |                  |                   |                 |
| 22   | 22-Mar-24    | Coastal Management: Essential for Conservation? | AF/EA    |                  |                   |                 |
|      | 29-Mar-24    | <b>Easter Break</b>                             |          |                  |                   |                 |
|      | 05-Apr-24    |                                                 |          |                  |                   |                 |
|      | 12-Apr-24    |                                                 |          |                  |                   |                 |
| 23   | 19-Apr-24    | Bracelet Bay Trip (porpoise, shore inverts)     | AF/EA    |                  |                   |                 |
| 24   | 26-Apr-24    | Microplastics Practical                         | AF/EA    |                  |                   |                 |
| 25   | 03-May-24    | Revision                                        | AF       |                  |                   | Exam in May TBC |

## BUILDING WITH NATURE

- Are Current UK Coastal Defences Good Enough for Tomorrow? An Assessment of Vulnerability to Coastal (tandfonline.com)